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Seasonal incidence of tomato fruit borer and efficacy of chemical, Bio insecticides and *Ha*NPV against *Helicoverpa armigera* in Tomato

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Abstract
An investigation was undertaken with an objective to assess the seasonal incidence and efficacy of chemical insecticides, NSKE and *Ha*NPV against tomato fruit borer. The occurrence of tomato fruit borer in *Rabi* season commenced from 6th standard week (February second week) with an average 0.32 larvae per plant. It gradually increased and reached peak level of 5.98 larvae per plant at 12th standard week (March last week). Thereafter, declined trend was observed. The percent of fruit borer infestation during third, seventh and fourteenth day after spraying revealed that Spinosad 45% SC, Indoxcarb 14.5% SC and Chlorpyrifos 20 EC were found superior. Minimum per cent of fruit infestation was observed in spinosad 45% SC (7.37%) followed by indoxcarb 14.5% SC (12.54%) and chlorpyrifos 20 EC (13.76%) respectively. The highest yield was registered in sprays of spinosad 45% SC (198 q/ha) followed by indoxcarb 14.5% SC (180 q/ha) and chlorpyrifos 20 EC (169 q/ha) over 62 q/ha yield of untreated check.

Keywords: efficacy, insecticides, *Ha* NPV, helicoverpa, NSKE

Introduction
Tomato is one of the most popular and widely grown vegetables in the world. Among various insects fruit borer (*Helicoverpa armigera*) is one of the most important devastating pests of tomato. It is a key pest as it attacks fruits and makes fruits unfit for human consumption (Katroju *et al.*, 2014) [5]. It causes 40-50 per cent yield loss which limits the production and market value of crop produce (Meena and Raju, 2014) [6]. Therefore it is necessary to manage this pest for better yield. With this background the present study was framed and conducted to know the seasonal incidence of fruit borer and efficacy of certain chemical insecticides, NSKE and *Ha*NPV against tomato fruit borer to identify the effective chemical for fruit borer management.

Materials and Methods
The present investigation was carried out by conducting the field experiments during Rabi 2015-16 at the Central research farm of Department of Entomology, SHUATS, Allahabad, Uttar Pradesh. The experimental material for this study consisted of Pusa Rubi variety of tomato and planted in two separate contiguous blocks in Randomized Block Design with eight treatments including an untreated control with three replications by following all the recommended package of practices to raise the healthy crop.
The plot size of 2m x 2m and spacing of 60 and 45 cm between rows and plants was maintained. Spraying was done with the help of a knapsack sprayer. Sprays were initiated on reaching 5 to 10 per cent fruit damage by the borer and repeated twice during the crop season as and when the infestation exceeded 5 to 10 per cent.
Observations on per cent infestation of fruit by the borer were recorded on five randomly selected plants per plot during the vegetative stage of crop and number of infested fruits at respective days. From these data the percentage infestation of fruit damage was worked out subjected to statistical analysis. The economics of the insecticidal treatments was also determined through cost benefit ratio analysis. Seasonal incidence also recorded in separate three plots of size 5m x 3m at different places within university farm. Observations were taken daily to evaluate the incidence of key pest of tomato.

Results and Discussion
The results revealed that at three days after spray with Spinosad 45 SC was most effective with minimum per cent fruit infestation (8.94%) followed by Indoxcarb 14.5 SC (14.35%) and Chlorpyriphos 20 EC (16.03 %) fruit damage.

Plots treated with Novaluron 10 EC, Quinolphos 25 EC, NSKE 5% and *Ha*NPV recorded 22.67, 23.16, 26.50 and 28.46 per cent fruit infestation respectively. In control the fruit infestation was 31.14 per cent (Table 1). In Seven days after first spray, Spinosad 45 SC was best treatment with 6.84% fruit infestation followed by Indoxcarb 14.5 SC and Chlorpyriphos 20 EC with fruit infestation 13.26 and 14.00 per cent respectively. Fourteen days after first spray also revealed, Spinosad 45 SC as best treatment with 9.43 per cent fruit infestation followed by Indoxcarb 14.5 SC and Chlorpyriphos 20 EC with fruit infestation of 16.01 and 17.83 per cent respectively.

The mean incidence of fruit borer on tomato fruits, one day prior to second spray, varied from 9.43 to 30.38 per cent in different treatments and 33.59 in control. Three days after the spray of Spinosad 45 SC had the least fruit damage (6.95 %) followed by Indoxcarb 14.5 SC and Chlorpyriphos 20 EC with fruit infestation 12.70 and 13.05 per cent respectively. The chemicals Novaluron 10 EC, Quinolphos 25 EC and NSKE 5% recorded 16.03, 18.20 and 24.05 per cent fruit infestation respectively. While *Ha*NPV was least effective treatments with 27.86 per cent fruit infestation as against 33.95 per cent in control. A similar trend was evident after seven days of the second spray, *i.e*. Spinosad 45 SC had minimum per cent fruit infestation with 5.72 per cent followed by Indoxcarb 14.5 SC, Chlorpyriphos 20 EC, Novaluron 10 EC, Quinolphos 25 EC, NSKE 5% and *Ha*NPV with 8.85, 10.11, 14.32, 16.01, 20.01 and 23.86 per cent respectively. The same trend was observed after fourteen days of the second spray, *i.e*. Spinosad 45 SC as minimum fruit infestation (6.36 %) followed by Indoxcarb 14.5 SC, Chlorpyriphos 20 EC, Novaluron 10 EC, Quinolphos 25 EC, NSKE 5% and *Ha*NPV with 10.08, 11.59, 15.52, 17.14, 22.03 and 25.21 per cent respectively (Table 2 & 3). The minimum per cent fruit infestation was recorded in Spinosad 45 SC. The present result is in agreement with the findings reported by Meena and Raju (2014) [6], Katroju *et al.* (2014) [5], Ghosh *et al. (*2010). Indoxcarb 14.5 SC was found to be next effective treatment and its results are supported by Ambule *et al.* (2015) [1], Meena and Raju (2014) [6]. Third effective treatment was Chlorpyriphos 20 EC and its results are supported by Hussain and Bilal (2007) [3].

The results pertaining to seasonal incidence of key pest of tomato are shown in Table 4. The incidence of tomato fruit borer was commenced from 6th standard week with an average 0.32 larvae per plant. The tomato fruit borer population increased and gradually reached peak level of 5.98 larvae per plant at 12th standard week (March last week). Thereafter, declined trend was observed due to rise in temperature. These results are in general agreement with Meena and Bairwa (2014) [7], Singh *et al*. (2011) [9], Selvraj and Bisht (2014) [8].

All the treatment was recorded significantly higher yield. The highest yield was recorded in T_1 spinosad 45% SC (198 q/ha), followed by T_3 (180 q/ha), T_5 (169 q/ha), T_4 (154 q/ha), T_2 (140 q/ha), T_6 (110 q/ha), T_7 (95 q/ha) as compared to control T_0 (62 q/h). Similar results were also reported by Ghosal *et al.* (2012) and Jat and Ameta (2013) [4]. The second best treatments was indoxcarb 14.5% SC with yield of tomato fruit (180q/ha). Similar results were also reported by Ambule *et al.* (2015) [1] with yield of (213q/ha). Ghosal *et al.* (2012) was also reported with yield of (236q/ha). Among all the treatments studied the best and most economical treatment was T_1 spinosad 45% SC with cost: benefit ratio of 1:6.09 followed by T_3 (1:5.54), T_5 (1:5.29), T_4 (1:4.75), T_2 (1:4.40), T_6 (1:3.47), T_7 (1:2.97) as compared to control T_0 (1:1.98). These results are supported by reports of Meena and Raju (2014) [6].

Table 1: Efficacy of chemical insecticides, NSKE and *Ha*NPV against tomato fruit borer, on tomato during *Rabi* season of 2015-2016 (1st Spray)

Treatments		% Infestation				
		Before	3 DAS	7 DAS	14 DAS	Mean
T_1	Spinosad	13.79 (21.75)	8.94 (17.38)	6.84 (15.14)	9.43 (17.86)	8.40 (16.80)
T_2	Quinolphos	28.47 (32.23)	23.16 (28.75)	21.96 (27.92)	24.55 (29.68)	23.22 (28.79)
T_3	Indoxcarb	21.41 (27.55)	14.35 (22.25)	13.26 (21.34)	16.01 (23.57)	14.54 (22.39)
T_4	Novaluron	26.50 (31.97)	22.67 (28.42)	20.66 (27.02)	24.05 (29.35)	22.46 (28.26)
T_5	Chlorpyriphos	21.96 (27.92)	16.03 (23.59)	14.00 (21.96)	17.83 (24.96)	15.95 (23.50)
T_6	Nske	31.14 (33.90)	26.50 (30.97)	24.5 (29.65)	27.86 (31.84)	26.28 (30.82)
T_7	*Ha* NPV	32.28 (34.60)	28.46 (32.22)	27.2 (31.42)	30.38 (33.43)	28.68 (32.36)
T_0	Control	28.50 (32.24)	31.14 (33.90)	32.28 (34.60)	33.59 (35.40)	32.33 (34.64)
Overall Mean		25.14	21.39	20.08	22.96	21.48
F- test		NS	S	S	S	S
S. Ed. (±)		1.26	0.75	0.72	0.66	0.48
C. D. (P = 0.05)		2.70	1.61	1.55	1.42	1.03

*Figures in parenthesis are arc sin transformed values

Table 2: Efficacy of chemical insecticides, NSKE and *Ha*NPV against tomato fruit borer on tomato during *Rabi* season of 2015-2016 (2nd Spray)

Treatments		% Infestation				
		Before	3 DAS	7 DAS	14 DAS	Mean
T_1	Spinosad	9.43 (17.86)	6.95 (15.26)	5.72 (13.82)	6.36 (14.56)	6.34 (14.57)
T_2	Quinolphos	24.55 (29.68)	18.20 (25.26)	16.01 (23.57)	17.14 (24.43)	17.11 (24.43)
T_3	Indoxcarb	16.01 (23.57)	12.70 (19.51)	8.85 (17.29)	10.08 (18.46)	10.54 (18.44)
T_4	Novaluron	24.05 (29.35)	16.03 (23.59)	14.32 (22.22)	15.52 (23.11)	14.95 (22.73)
T_5	Chlorpyriphos	17.83 (24.96)	13.05 (21.16)	10.11 (18.88)	11.59 (19.87)	11.58 (19.98)
T_6	Nske	27.86 (31.84)	24.05 (29.35)	20.01 (26.56)	22.03 (27.97)	22.03 (27.96)
T_7	*Ha*npv	30.38 (33.43)	27.86 (31.84)	23.86 (29.22)	25.21 (30.12)	25.64 (30.40)
T_0	Control	33.59 (43.16)	33.95 (35.84)	36.01 (36.86)	38.51 (38.34)	36.15 (36.94)
Overall Mean		22.96	18.91	16.99	18.30	18.06

F- test	S	S	S	S	S
S. Ed. (±)	0.66	0.7	0.69	1.25	1.01
C. D. (P = 0.05)	1.42	1.51	1.48	2.69	2.17

*Figures in parenthesis are arc sin transformed values.

Table 3: Efficacy of certain chemical insecticides, NSKE and *Ha*NPV against tomato fruit borer in tomato during *Rabi* season of 2015-2016 (1st and 2nd Spray Overall Mean)

Treatment No.	Treatment	% fruit infestation		
		1st Spray Mean	2nd Spray Mean	Overall Mean
T_1	Spinosad	8.40 (16.80)	6.34 (14.57)	7.37 (15.68)
T_2	Quinolphos	23.22 (28.79)	17.11 (24.43)	20.16 (26.61)
T_3	Indoxcarb	14.54 (22.39)	10.54 (18.44)	12.54 (20.41)
T_4	Novaluron	22.46 (28.26)	14.95 (22.73)	18.70 (25.49)
T_5	Chlorpyriphos	15.95 (23.50)	11.58 (19.98)	13.76 (21.74)
T_6	Nske	26.28 (30.82)	22.03 (27.96)	24.15 (29.39)
T_7	*Ha* NPV	28.68 (32.36)	25.64 (30.40)	27.16 (31.38)
T_0	Control	32.33 (34.64)	36.15 (36.94)	34.24 (35.79)
Overall Mean		21.48	18.06	19.77
F- test		S	S	S
S. Ed. (±)		0.48	1.01	0.74
C. D. (P = 0.05)		1.03	2.17	1.6

*Figures in parenthesis are arc sin transformed values.

Table 4: Seasonal incidence of tomato fruit borer during *Rabi* season

Standard week	No. of larva/plant	Temperature		Humidity %		Rainfall (mm)	Wind Velocity	Sunshine (hr/day)
		Max.	Min.	Morning	Evening			
47th	0	31.4	11.4	92	54	0	0.62	8.4
48th	0	31.4	15.8	90	56	0	0.74	8.4
49th	0	27.8	13	92	65	0	1.04	7.8
50th	0	26.2	13	92	63	0	0.92	6.4
51st	0	25.4	10.4	92	61	0	1	5.8
52nd	0	23.6	8.8	92	58	0	0.58	6.8
1st	0	24	9.2	92	58	0	2.04	7.6
2nd	0	29.4	9	90	51	0	1.29	7.8
3rd	0	26	10	92	61	0	0.92	8.4
4th	0	23.6	6	93	54	0	1.33	7
5th	0	30.6	12.6	89	45	0	0.91	8.2
6th	0.32	29.6	11.4	90	44	0	1.12	8
7th	1.25	30.6	12.2	88	44	0	1.62	8.4
8th	2.2	34.2	12.6	89	42	0	1.04	8.4
9th	2.75	33.2	12.4	87	42	0	1.44	8.2
10th	3.78	36.8	18	87	42	0	1.12	8
11th	5,72	36.6	19	86	42	0	1.33	8
12th	5.98	34.4	16	88	47	0	1.5	7.8
13th	3.78	38	18	86	44	0	1.12	7
14th	2.75	39.25	21.00	87	42	0	1.04	8.2
	r	0.601	0.660	-0.108	-0.448	-0.085	0.502	0.614
	t	3.280	3.827	-0.475	-2.184	-0.373	2.531	3.386
	F- test	S	S	NS	S	NS	S	S

Conclusion

From the critical analysis of the present findings it was concluded that among all the treatments spinosad 45% SC proved that best treatment over control followed by indoxcarb 14.5% SC, chlorpyrifos 20EC, novaluron 10% EC, quinolphos 25% EC, NSKE 5% and *Ha*NPV. spinosad proved to be the best treatment in managing fruit damage caused by *Helicoverpa armigera* on tomato. Therefore, insecticides of short residual effect and biopesticide like spinosad may be useful in devising proper integrated pest management strategy against tomato fruit borer.

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